5. Multiple cropping on paddy field (1977—1979)

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Several cropping patterns in paddy field were carried out in 1977—1979 to examine their productivity and water efficiency. Research findings obtained in the previous experiments on water consumption, crop rotation and irrigation engineering were combined together in the experimental design as trials.

Experiment in 1977

Materials and method

1. Cropping patterns:
   1) Rice (Single cropping in wet season)
   2) Soybean — Rice
   3) Mungbean — Rice
   4) Maize — Rice
   5) Mungbean —Soybean — Rice
   6) Peanut — Soybean — Rice
   7) Maize — Soybean — Rice
2. Irrigation for upland crops
   Furrow irrigation was applied by following methods:
   1) Customary method: To irrigate each furrow of 80 m in length by using ϕ41 mm siphons; and stop to irrigate when the front of water flow reaches the end of a furrow.
   2) Improved method: To irrigate similarly as mentioned above by using ϕ50 mm siphons. This method intended to save time by increasing the quantity of water flow as well as irrigate at appropriate rates according to the growth stage of each crop.

   The time required for and the amount of irrigation to each plot is summarized in Table 5-1.

Planting and harvesting time of the cropping patterns

	Cropping pattern	1976 Dec.	1977 Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.
1.	R									8 --------	Rice	-----	17
2.	S-R				9 -----	Soybean	---	20		8 --------	Rice	-----	17
3.	Mg-R					29 -----	Mungbean	---	13	8 --------	Rice	-----	17
4.	Mz-R			16 ------	Maize	-----	24			8 --------	Rice	-----	17
5.	Mg-S-R		18 ----	Mungbean	--11	21-----	Soybean	---	12	8 --------	Rice	-----	17
6.	P-S-R	24----------		Peanut	----11	21-----	Soybean	---	12	8 --------	Rice	-----	17
7.	Mz-S-R	24---------	Maize	--------	4	21-----	Soybean	---	12	8 --------	Rice	-----	17

4. Varieties:
   Soybean: SJ 2, Mungbean: SPR No.1, Peanut: Tainan No.6
   Maize: Suwan No.1, Rice: RD7
5. Fertilizer application (Kg/ha):

	N	P_2O_5	K_2O
Leguminous:	20	40	40
Maize:	150*	80	40
Rice:	40*	25	0

   * A half of the amount was top-dressed.
6. Spacing
   Leguminous crops : 75 cm × 20 cm, 2 plants/hill
   Maize : 75 cm × 25 cm, 1 plant/hill
   Rice : 25 cm × 25 cm, 3 seedlings/hill
7. Plot size:
   80 m × 7.5 m, 1 replication
8. Incorporation of crop residues
   Plant residues of soybean, mungbean and maize were plowed into soil after harvesting pods or ears, but whole plants of peanut were carried away from the field for processing.

Results

Upland crops

1. The improved irrigation method intended to highten the water efficiency by saving time and water amount required. Although this method saved time, irrigation amount was not so different from the customary one as shown in Table 5-1. This was because the front of water flow reached the midway of a furrow quickly by increasing the quantity of water flow but it took time after that to reach the end of a furrow. Thus, in examining the growth and yield of the upland crops, the relevant figures of both the irrigation plots were averaged as shown in Table 5-2.
2. Soybean and mungbean, the major crops in the dry season, yielded very little as soybean seeds or mungbean pods did not develop owing to unidentified causes (which later were identified as damages by insects). Thus, the effect of the first crop on the second crop in the dry season could not be checked, although the initial growth of soybean succeeding to mungbean and peanut (plot No.5 and 6, respectively) was more vigorous than that of soybean succeeding to maize (plot No.7).
3. Significant possitive correlation between plant height and ridge height was observed in maize, peanut, mungbean and soybean. Such a trend was especially clear in case of maize. This suggests that making up ridges to appropriate height has favorable effects on plant growth by protecting from wet injury caused by stagnant water in furrows after irrigation (Table 5-3).

Rice:

The results are summarized in Table 5-4 and 5.

1. The growth of rice succeeding to leguminous crops in the triple cropping systems (plot No.5, 6 and 7) was more vigorous than that of single crop of rice (plot No.1), but there were not big differences in grain yield among those plots.
2. The growth and yield of rice succeeding to maize in the double cropping system

(plot No.4) was worst among all the plots. The amount of nitrogen absorption by rice plant in this plot was less than in other plots.

3. The highest yield of rice crop was obtained in the triple cropping system of 'maize-soybean-rice' (5.17 t/ha), followed by 'peanut-soybean-rice' and 'maize-soybean-rice'.

Experiment in 1978

Materials and method

1. Cropping pattern:
   Two cropping patterns growing sesbania and crotalaria as green manures for the succeeding crops (corresponding to plot No.2 and 6, respectively) were newly added. The plot No.6 was divided into two sub-plots in one of which the leaped crotalaria was plowed into soil and in the other the crotalaria was mulched.

Planting and harvesting time of the cropping patterns

Cropping pattern	1978 Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1. R									18	----- Rice	------	21
2. Se - R						8	---Sesbania---	5	18	----- Rice	------	21
3. S — R						8	---Soybean ---	14	18	----- Rice	------	25
4. Mg - R						8	-- Mungbean-18		18	----- Rice	------	21
5. Mz - R				4	----Maize------	10			18	----- Rice	------	25
6. Cr — Mz - R	23--	Crotalaria--3		4	----Maize------	10			18	----- Rice	------	21
7. Mz — S - R	23	-------Maize----------1				8	-----Soybean---	14	18	----- Rice	------	25
8. P — S — R	23	------Peanut ---------	3			8	-----Soybean----	14	18	----- Rice	------	25
9. Mg — S — R	23	-- Mungbean--28				8	----Soybean---	14	18	----- Rice	------	25

2. Irrigation for upland crops:
   The crops were irrigated in similar way as 1977 by using ϕ50 mm siphons. The rate of irrigation was 6 to 8 mm/day in average throughout the growth period including rainfall.
3. Varieties:
   Same varieties as in 1977 were used except soybean for which SJ 4 was adopted.
4. Fertilizer application:
   Same as in 1977 except the following; a half of nitrogen applied to leguminous crops was top-dressed. However, those crops seeded on June 8 were not top-dressed because of very wet field conditions in those days resulting from the continuous rainy weather.
5. Spacing:
   Same as in 1977. In addition, sesbania and crotalaria were sown with the rates of 7 and 25 kg/ha, respectively.
6. Plot size:

80 m × 10.5 m for each plot; one replication. Plot No.6 was divided into two sub-plots (40 m × 10.5 m) for different treatment of the leaped crotlaria; namely, plowing in and mulching.

7. Incorporation of crop residues:
   Similarly done as in 1977 except that the whole plant of soybean was plowed into soil before maturity because of the reasons described below.

Results

Upland crops:

1. In this dry season, the crops were not planted as scheduled. The shortage of irrigation water in the reservoirs on the upper stream forced the authors to postpone planting of the first crop for nearly one month. Thus, planting of the second crop fell in early June when prevailing rainy weather made the land preparation works very difficult.
2. Under this condition, the first crop such as mungbean, peanut, maize and crotalaria yielded fairly well; but soybean, the second crop seeded on June 8, poorly standed and was leaped before maturity to prepare for transplanting rice, the next crop (Table 5-6).
3. Dry weight of crotalaria was 8.09 t/ha when it was plowed in or mulched; its nitrogen content was estimated at 151.8 kg/ha (Table 5-7). Its effect on the yield of succeeding maize crop was bigger when it was plowed into soil than mulched. This was partly due to wet injuries occurred in the mulched plot. However, this effect was not so clear when the maize yield was compared with that of Plot No.5 where maize was grown without any preceding crop (Table 5-6).
4. Dry weight of sesbania was 5.6 t/ha; its nitrogen content is estimated at 82.3 kg/ha (Table 5-8).
5. A colse negative correlation between plant height of maize and soil moisture content, as well as a close possitive one between the same and ridge height were observed (Fig. 5-1).

Rice:

1. Rice in the triple cropping system including soybean as its component yielded the highest (Table 5-9 and 10).
2. Rice succeeding to maize in double cropping system (Plot No.5) grew less vigorously during the vegetative growth stage. It yielded comparatively low but still higher than the Plot No.1, single crop of rice.
3. Incorporation of crotalaria seemed effective on rice yield when Plot 5 and 6 were compared.

Experiment in 1979

Materials and method

1. Cropping pattern:

Planting and harvesting time of the cropping patterns

Cropping pattern	1979 Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
1. R								21	----- Rice	----	27 (28)
2. Mz ------ R	25	-------	Maize	-------	8			21	----- Rice	----	27 (28)
3. S ------- R	25	------	Soybean	------	8			21	----- Rice	----	27 (28)
4. S -- Mg-- R	25	------	Soybean	-----	11	17 ---	Mungbean -- 7	21	----- Rice	----	27 (28)
5. Mg-- R						17 ---	Mungbean -- 7	21	----- Rice	----	27 (28)

Note : The harvesting date of rice in parentheses indicates the date of the plot with higher amount of nitrogen top-dressing.

2. Fertilizer application:
   Same as in 1977, except rice for which two different rates of fertilizers were applied as follows:
   a) N: basal 20 plus top-dressing 5; P_2O_5: 25 (kg/ha)
   b) N: basal 20 plus top-dressing 30; P_2O_5: 25 (kg/ha)
3. Plot size:
   80 m × 21 m, except the plot of rice single cropping (plot No.1) sized 80 m × 10.5 m; one replication. For rice crop, each plot was divided into two sub-plots to which the different rates of fertilizer mentioned above were applied.
4. Others such as irrigation, varieties, spacing and incorporation of crop residues were similar as in 1977. Irrigation and rainfall during upland crops growing are summerized in Table 5-11.

Results

Upland crops:

As an attempt, the input and output balance for 4 cropping patterns (plot No.2, 3, 4 and 5) during the period of growing upland crops was estimated as shown in Table 5-13, 14 and 15. The estimation did not count the labours required for ordinary field management (excluding hired labours), based on the assumption that such labours were to be provided by farm families. The results indicated that the input and output balance is negative for maize (No.2) and positive for others, out of which soybean (No.3) was best. Although maize yield in this experiment was extremely low, it was suggested that growing maize in paddy field with application of much nitrogen was not economical.

Rice:

1. Rice growth in terms of colouring, plant height, tiller number and top dry weight was better in the plot No.4 and 5, where rice was transplanted soon after mungbean harvest, as compared with other plots.

2. Effect of increased application of nitrogen for top-dressing was noticeable only in top dry weight (Table 5-16) but neither in plant height nor tiller number.
3. Out of the yield components, only the number of spikelets per panicle differed appreciably among the plots; it was least in the plot succeeding to maize (No.2) and most in the plots succeeding to soybean (No.3) and 'soybean-mungbean' (No.4) (Table 5-17).
4. Reflecting the aforementioned, the rice yield succeeding to fallow (No.1) and maize (No.2) was relatively low; that succeeding to soybean (No.3) and 'soybean-mungbean' (No.4) was relatively high. However, rice suceeding to mungbean (No.5) did not yield so high as expected from its vigorous growth; straw weight was highest in this plot (Table 5-18).
5. Application of 30 kg/ha of nitrogen for top dressing highten the low yields of the plot No.1 and 2 mentioned above up to the level nearly equal to the less fertilized (top-dressed with 5 kg/ha of nitrogen) part of the plot No.3 and 4. However, such increased application of nitrogen could not offset the aforementioned trend of rice yield among the plots.
6. The content of ammonium nitrogen of surface layer of each plot was checked before rice transplanting as shown in Table 5-19. Clear positive correlation was not found between these figures and the average rice yield of both the fertilization of each plot ($r = 0.120$: rice yield vs. ammonium introgen content of dried soil; $r = 0.719$ rice yield vs. the same of fresh soil).

Discussion

A series of experiments on multiple cropping on paddy field were carried out for 3 years since 1977 under the same design with a little modification in each year. Table 5-20 shows the rice yields of each cropping pattern during the period. It was very likely that the rice yields of single cropping (R plot) and double cropping with maize (Mz-R plot) were lower than those of other cropping patterns.

In this experiment, soybean and mungbean were plowed into soil before maturity similarly as green manures because of the failure in development of grains or pods due to insect attacks in 1977 and the delay of seeding due to the weather condition in 1978. It may not be realistic to grow rice or some upland crops after incorporation of fresh materials of leguminous crops which have been grown with fertilizer application as been done in this experiment. In 1979, however, both soybean and mungbean yielded fairly well; rice succeeding to these crops yielded higher than the R and Mz-R plots. Judging from the facts, leguminous crops could be recommended for inclusion into multiple cropping patterns on paddy field to maintain productivity of soils. The advantage in input and output balance of soybean and mungbean which was described before, also supports this idea form the economic points of view.

It was proved in the past experiment* that the content of ammonium nitrogen of paddy soil was at higher level when soybean was grown as the preceding crops than the case maize was grown. When soybean residues or other green manures incorporated in soils are considered to be sources of plant nutrients, the more residues may bring about better growth of the succeeding crops. Fig.5-2 was drawn to examine this idea by plotting the dry matter weight of soybean plowed into soil and the corresponding

* Takahashi, H. and Sasiprapa V. (1976): IV-2. Effect of preceding upland crops on growth and yield of rice.

figures indicating the growth and yield of rice under several cropping patterns carried out in 1978. Although the vegetative growth of rice was nearly in proportion to the top weight of soybean plowed into soil, the rice grain yield was not the case.

The previous experiment menthoned above* also suggested the suitable intervals to be kept from harvesting preceding upland crops to transplanting rice; that is, 3 months for maize (in case accompanied with increased fertilizer application to rice at its later growth stage) or 1 to 2 weeks (in case of ordinary fertilizer application to rice); and less than two months for soybean or peanut. Probably, this suggestion was theoritically correct, but the three year experience in undertaking the experiments on multiple cropping patterns led the authors to the idea that such suitable intervals would be some different year by year due to the climatic and some other conditions.

Also, the Experiment IV-7 proved that the season starting from January was best to stabilize soybean yield by escaping insect injuries. This factor has also to be taken into account in planning cropping patterns.

Table 5-1. Irrigation amount and time (1977)

Plot No.	Crop[1]	Period[2]	Irrigation[3]	Time			Irrigation amount[4]			Irrigation rate	
				1st Crop	2nd Crop	total	1st Crop	2nd Crop	total	1st Crop	2nd Crop
		days		min.			mm			mm/day	
2	S	104	I	274	—	274	704	—	704	6.8	—
			C	421	—	421	703	—	703	6.8	—
3	Mg	68	I	168	—	168	440	—	440	6.5	—
			C	237	—	237	395	—	395	5.8	—
4	Mz	96	I	237	—	237	637	—	637	6.6	—
			C	304	—	304	540	—	540	5.6	—
5	Mg—S	77, 78 (155)	I	157	228	385	397	580	978	5.2	7.4
			C	279	310	589	457	524	981	5.9	6.3
6	P—S	111, 78 (189)	I	238	192	430	647	540	1187	5.8	6.9
			C	326	249	575	568	461	1029	5.1	5.9
7	Mz—S	104, 78 (182)	I	274	221	495	705	604	1309	6.8	7.7
			C	341	266	606	567	485	1052	6.2	5.8

Remarks: 1) S: Soybean, Mg: Mungbean, Mz: Maize, P: Peanut.
2) Figures in parenthes mean the total of two crops.
3) I: Improved method, C: customary method
4) Rainfall during the growth periods is included in the irrigation amount.

Table 5-2. Yield, top dry weight and leaf area index of upland crops (1977)

Plot	Grain yield (t/ha)		Top dry weight (t/ha)			L A I	
	F	S	F	S	Total	F	S
2. S	0.0	—	4.30	—	4.30	5.49	—
3. Mg	0.0	—	3.26	—	3.26	3.15	—
4. Mz	3.80	—	10.34	—	10.34	3.43	—
5. Mg—S	0.08	0.0	1.98	9.76	11.74	0.98	6.04
6. P—S	1.96	0.0	6.31	12.74	19.05	4.79	8.46
7. Mz—S	2.19	0.0	8.49	12.10	20.58	2.82	8.03

Remarks: 1) The figures are the average of both the plots of irrigation (customary and improved).
2) F & S: First and second crop in dry season, respectively.
3) LAI: Leaf area index at maximum
4) The low yield in plot No.7 was due to damages by rats.

Table 5-3. Coefficient correlation between plant height of upland crops and ridge height where the plant stands (1977)

Upland crop	Plot No.	Days after seeding	Coefficient correlation
Maize	7	31	0.688***
Maize	4	34	0.552***
Peanut	6	31	0.342*
Mungbean	5	37	0.398*
Soybean	2	29	0.444**

Remarks: 40 plants were checked for each crop
* Significant at 5% level
** Significant at 1% level
** Significant at 0.1% level

Table 5-4. Heading date, top dry weight and nitrogen content in rice succeeding to upland crops (1977)

Plot.	Heading date	Top dry weight (g/m^2)				Nitrogen content in top							
						Aug. 15		Aug. 29		Sept. 12		Oct. 17	
		Aug. 15	Aug. 29	Sept. 12	Oct. 17	%	g/m^2	%	g/m^2	%	g/m^2	%	g/m^2
1. R	Oct. 13	7.68	54.4	193.6	747.2	3.15	0.24	3.27	1.78	1.77	2.47	0.98	7.33
2. S—R	12	8.16	72.0	230.4	736.0	2.83	0.23	2.70	1.94	1.75	4.03	1.09	8.04
3. Mg—R	12	6.72	60.8	262.4	811.2	3.08	0.21	3.15	1.92	1.71	4.49	1.11	9.00
4. Mz—R	14	7.68	52.8	174.4	723.2	2.64	0.20	2.64	1.39	1.85	3.23	1.08	7.83
5. Mg—S—R	11	8.48	92.8	382.4	792.0	3.15	0.27	3.27	3.03	1.85	7.08	1.17	9.23
6. P—S—R	11	9.60	97.6	328.0	851.2	3.53	0.34	3.34	3.26	2.25	7.38	1.17	9.97
7. Mz—S—R	11	10.56	78.4	324.8	867.2	3.15	0.33	3.15	2.47	2.03	6.59	1.21	10.53

Table 5-5. Grain yield and its components of rice in relation to preceding upland crops (1977)

	Plot	Grain yield	Number of panicles		Number of spikelets	Degree* of ripening	Wt. of 1000 full grains
		t/ha	/hill	/m²	/m²		g
1.	R	4.96	11.7	187	22785	21.8	28.5
2.	S—R	4.19	11.2	179	20043	20.9	27.8
3.	Mg—R	4.88	12.2	195	21170	23.1	28.8
4.	Mz—R	4.05	12.0	192	20057	20.2	27.4
5.	Mg—S—R	5.17	11.1	178	20587	25.1	29.9
6.	P—S—R	5.03	11.3	181	20062	25.1	29.7
7.	Mz—S—R	5.01	12.3	197	20022	25.0	29.8

Remarks: * Grain (unhusked full) yield in gram per 1,000 spikelets

Table 5-6. Grain yield and dry weight of upland crops (t/ha) (1978)

	Plot	Grain yield		Dry weight	
		1st crop	2nd crop	1st crop	2nd crop
1.	R	—	—		
2.	Se—R	—		5.60	
3.	S—R	—		3.07	
4.	Mg—R	0.13		1.12	
5.	Mz—R	2.24		8.12	
6.	Cr—Mz—R	—	2.43*	8.09	7.88*
			1.75**		7.19**
7.	Mz—S—R	4.29	—	9.06	2.03
8.	P—S—R	1.93	—	5.16	1.93
9.	Mg—S—R	0.64	—	1.58	1.07

Remarks: 1) Dry weight of soybean, mungbean and maize is that of top part only. In case of sesbania and crotalaria, it means dry weight of whole plant.
2) * Crotalaria was plowed in.
** Crotalaria was mulched.

Table 5-7. Nitrogen content and dry weight of crotalaria at leaping (1978)

	Root	Stem	Leaf blade	Flower	Total
Dry weight (kg/ha)	572.8	5316.8	1567.0	633.4	8090.0
Nitrogen content (%)	0.61	0.97	4.38	4.44	1.88
Nitrogen absorbed (kg/ha)	3.49	51.57	68.63	28.12	151.81

Table 5-8. Nitrogen content and dry weight of sesbania at leaping (1978)

	Root	Stem	Leaf blade	Total
Dry weight (kg/ha)	700.1	3338.7	1561.7	5600.5
Nitrogen content (%)	0.64	0.96	2.93	1.47
Nitrogen absorbed (kg/ha)	4.48	32.05	45.76	82.29

Table 5-9. Yield components and grain yield of rice (1978)

	Plot	Number of panicles	Number of spikelets	Percentage of ripened grains	Weight of 1,000 full grains	Full grain yield
		no./hill	no./panicle	%	g	t/ha
1.	R	11.3	111	58.4	28.2	3.06
2.	Se—R	11.8	128	62.8	29.4	4.14
3.	S—R	12.2	123	64.2	29.5	3.74
4.	Mg—R	11.9	127	60.1	28.7	4.00
5.	Mz—R	11.9	114	66.9	28.5	3.79
6.	Cr—Mz—R	13.5	115	62.1	29.0	4.14
7.	Mz—S—R	13.3	125	61.9	29.6	4.63
8.	P—S—R	13.0	123	64.3	29.2	4.69
9.	Mg—S—R	13.1	123	62.2	29.3	4.47

Remarks: 1) Number of spikelets were counted for grains sunk in the solution of 1.06 specific gravity.
2) Weight of 1,000 full grains and grain yield are based on 14% moisture content.

Table 5-10. Top dry weight, nitrogen content and heading date of rice (1978)

	Plot	Top dry weight (g/m²)		N content (%)		Heading
		Oct. 18	Nov. 21	Oct. 18	Nov. 21	date
1.	R	95	561	2.58	1.88	Nov. 21
2.	Se—R	151	718	2.94	2.01	20
3.	S—R	176	860	2.32	2.15	23
4.	Mg—R	120	695	2.16	1.96	21
5.	Mz—R	85	627	2.16	2.09	22
6.	Cr—Mz—R	116	679	2.14	2.10	21
7.	Mz—S—R	175	828	2.84	2.11	23
8.	P—S—R	161	826	2.12	2.31	23
9.	Mg—S—R	141	757	1.97	2.23	23

Remarks: Nitrogen was analyzed on whole top part of plants for the samples taken on Oct. 18; and on leaves for those done on Nov. 21.

Table 5-11. Irrigation and rainfall during the growing period of upland crops (1979)

Crop	Period	Irrigation time	Irrigation amount		Total rainfall
			Mean/day	Total	
			mm	mm	mm
Maize	Before flowering	5	4.6	214	0
	After flowering	6	5.2	241	11
	Total	11		455	11
Soybean	Before flowering	4	4.4	144	0
	After flowering	7	5.3	339	11
	Total	11		483	11
Mungbean	Before flowering	1	3.0	117	154
	After flowering	3	2.9	103	107
	Total	4		220	261

Table 5-12. Yield components and grain yield of upland crops (1979)

Plot		Crop	Number of hills	Number of pod (ear)s	Number of grains	100 grain weight	Grain yield
			no.×10³/ha	no./hill	no./pod	g	t/ha
2.	Mz——R	Maize	49.6	(0.82)	13.9×13.1cm*	20.9	1.47
3.	S———R	Soybean	57.2	145	1.8	15.4	1.97
4.	S—Mg—R	Soybean	50.6	157	1.8	14.9	1.43
4.	S—Mg—R	Mungbean	53.7	14.4	10.1	7.4	0.84
5.	Mg—R	Mungbean	53.7	13.9	12.0	7.0	1.02

Remarks: Grain yield and 100 grain weight are based on 13% moisture content.

* Number of grain rows × ear length.

Table 5-13. Input working hours per hectare in the main management works for upland crops (1979)

	Operation	Maize	Soybean	Mungbean	Remarks
1)	Speed bed preparation				
	Plowing	3h.	3h.	3h. 30 min.	Rotavator (one way) 170 cm width
	Harrowing	5h. 30 min. (twice)	5h. 30 min. (twice)	3h.	Rotavator
	Ridging	3h.	3h.	3h.	3 row ridger (including making operation)
2)	Fertilizer application	7h.	7h.	7h.	Manual labour of 9 persons
3)	Seeding	29h.	35h.	24h.	Manual labour of 9 persons
4)	Pests & weed control				
	Hand weeding	590h. (once Feb. 22)	720h. (once Feb. 23)		with spades, 22 persons
	Herbicide spraying			22h. (800 lit)	Knapsack type hand sprayer of 15 lit. capacity; one pair of 2 persons
	Insecticide spraying (1)	12h. (500 lit) (Feb. 10)	12h. (500 lit) (Feb. 7)	12h. (500 lit) (May 28)	The same sprayer as herbicide spraying
	(2)		20h. (800 lit) (Feb. 19—20)	15h. (600 lit) (Jun. 22)	do.
	(3)		14h. (1500 lit) (Mar. 7)	10h. (1000 lit) (Jun. 29)	Knapsack type power sprayer with 10 lit capacity
	(4)		do. (Mar. 13)	do. (Jul. 12)	
	(5)		do. (Mar. 20)		
	(6)		do. (Mar. 27)		
	(7)		do. (Apr. 4)		
5)	Harvesting	36h.	136h.	254h. (175+79)	Manual labour of 7—9 persons

Remarks: 1) The data were obtained from the observation in the plots of 1680 square meters (80 m × 21 m) each. Two replications for soybean and mungbean; without replication for maize.
2) Harvesting was carried out by picking ears by hand in maize, cutting stems with rice sickles in soybean and picking pods by hand in mungbean.

Table 5-14. Input costs per hectare for growing upland crops (1979)

Materials	Maize		Soybean		Mungbean		Unit price
Fertilizer	Baht (Kg/lit. per ha.)		Baht (Kg/lit. per ha.)		Baht (Kg/lit. per ha.)		
Ammonium sulphate	1785	(714)	237.5	(95)	237.5	(95)	2.5 baht/kg (in January, 1979)
Double superphosphate	1034	(188)	550	(100)	550	(100)	5.5 baht/kg (do)
Potassium chloride	415	(83)	335	(67)	335	(67)	5 baht/kg (do)
Pesticides							
Alachlor					758	(5.83)	130 baht/lit. (in May 1979)
Dimethoate			161.5	(1.7)	161.5	(1.7)	95 baht/lit. (in February, 1979)
Monocrotophos	90	(0.5)	1494	(8.3)	468	(2.6)	180 baht/lit. (do)
Total	3324		2778		2510		

Remarks: The prices of the materials were referred to retail prices at Suphanburi.

Table 5-15. Estimation of input and output balance per hectare in each cropping pattern (Baht/ha) (1979)

Input output balance	Cropping pattern				Remark
	Maize	Soybean	Soybean—Mungbean	Mungbean	
1) Input cost					
Seed bed preparations	938	938	1875	938	Based on the customary cost (150 Baht/rai)
Purchased materials	3324	2778	5288	2510	Fertilizers and pesticides
Seeds	300	600	960	360	Maize: 6 Baht/kg Soybean: } 12 Baht/kg Mungbean: } 12 Baht/kg
Hand weeding	1845	2250	2250		25 Baht per man.day (8 hour labour a day)
Total	6407	6566	10373	3808	
2) Output income	3013	10553	12723	4848	price in Baht/100 kg Maize: 255—260 Soybean: 590—630 Mungbean: 635—750
3) Balance	-3394	3987	2350	1040	

Remarks: 1) Labours required for ordinary farm management works were not computed, assuming that such labours were provided by each farm housefold on self-sufficient basis.

2) Output incomes were estimated based on the crop yields harvested from the entire plots concerned, instead of estimating from sampling. The crop yields in each cropping pattern were as follows:

Maize (Mz—R)	: 1.17 ton/ha
Soybean (S—R)	: 1.73
Soybean (S—Mg—R)	: 1.45
Mungbean (Mg—R)	: 0.70
Mungbean (S—Mg—R)	: 0.56

Mungbean pods were harvested at one time.

3) The grain price of each crop was referred to Thai Farmer Journal, Vol. 6, No.7 (July 1979).

4) Hand weeding was not done for mungbean.

Table 5-16. Top dry weight, nitrogen content of leaves and heading date of rice (1979)

Plot	Top dry weight (g/m²)				Nitrogen content (%)				Heading date	
	Sep. 20	November 1			Sep. 20	November 1				
		N 5 kg/ha	N 30 kg/ha	Mean		N 5 kg/ha	N 30 kg/ha	Mean	N 5 kg/ha	N 30 kg/ha
1. R	59	719	755	737	1.61	0.87	1.01	0.94	Oct. 31	Nov. 1
2. Mz——R	71	636	689	663	1.30	1.16	1.04	1.10	Oct. 30	Oct. 31
3. S——R	80	713	820	767	1.91	1.04	1.02	1.03	Oct. 31	Oct. 31
4. S—Mg—R	106	746	869	808	1.71	0.93	1.16	1.05	Oct. 31	Nov. 1
5. Mg—R	103	759	904	832	1.62	0.97	0.99	0.98	Oct. 31	Nov. 1
Mean	84	715	807		1.63	0.99	1.04		Oct. 31	Nov. 1

Remarks: Nitrogen was analyzed on whole top part of plants for the samples taken on Sept. 20; and on leaves for those done on Nov. 1.

Table 5-17. Yield components of rice (1979)

Cropping pattern	Number of panicles per hill			Number of spikelets per panicle			% of ripened grains			Weight of 1,000 full grains (g)		
	N 5 kg/ha	N 30 kg/ha	Mean	N 5 kg/ha	N 30 kg/ha	Mean	N 5 kg/ha	N 30 kg/ha	Mean	N 5 kg/ha	N 30 kg/ha	Mean
1. R	12.3	12.1	12.2	80.7	83.1	81.9	81.9	80.5	81.2	27.7	28.2	28.0
2. Mz——R	12.0	12.2	12.1	76.7	79.4	78.1	79.6	84.4	82.0	28.5	29.1	28.8
3. S———R	12.1	13.1	12.6	92.4	93.2	92.8	81.7	80.6	81.2	28.8	28.4	28.6
4. S—Mg—R	11.8	12.8	12.3	89.3	94.6	92.0	84.2	80.1	82.2	29.5	28.2	28.9
5. Mg—R	12.1	12.7	12.4	85.7	85.7	85.7	83.3	82.3	82.8	28.7	29.1	28.9
Mean	12.1	12.6		85.0	87.2		82.1	81.6		28.6	28.6	

Remarks: 1) Number of spikelets was coounted for grains sunk in water.
2) Weight of 1,000 full grains is based on 14% moisutre content.

Table 5-18. Yield of rice (1979)

Cropping pattern	Full grain wt. (t/ha)			Straw weight (t/ha)			Grain straw ratio (%)		
	N 5 kg/ha	N 30 kg/ha	Mean	N 5 kg/ha	N 30 kg/ha	Mean	N 5 kg/ha	N 30 kg/ha	Mean
1. R	4.03	4.24	4.14	4.17	4.53	4.35	98	94	95
2. Mz——R	3.85	4.44	4.15	3.88	4.83	4.36	99	92	95
3. S———R	4.53	5.06	4.80	4.86	5.44	5.15	93	93	93
4. S—Mg—R	4.35	4.99	4.67	5.29	5.98	5.64	82	83	83
5. Mg—R	4.28	4.36	4.32	5.82	6.20	6.01	74	70	72
Mean	4.21	4.62		4.80	5.40		88	86	

Table 5-19. Ammonium nitrogen contents in soil after incubation at 40°C for 4 weeks under submerged condition (1979)

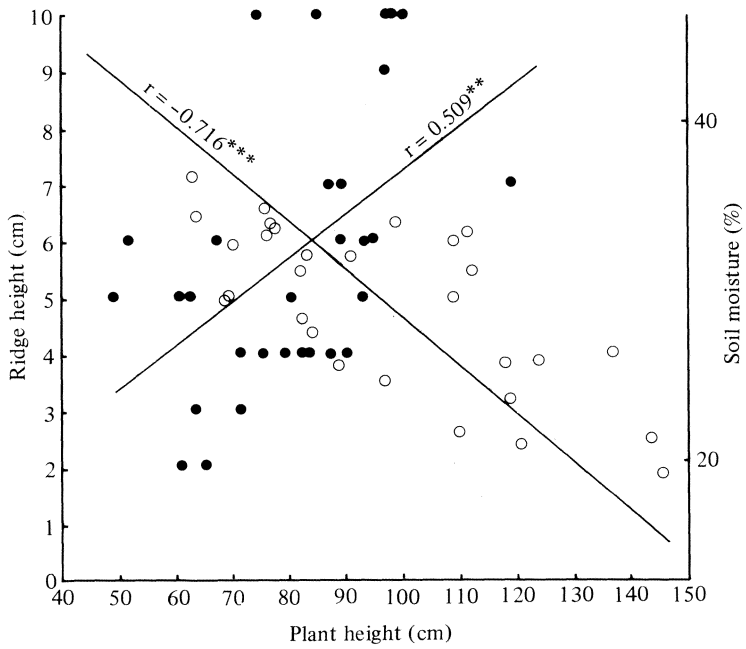
Cropping pattern	Moisture (%)	MH_4-N (mg/100g. dry soil)	
		Dried soil*	Fresh soil**
1. R	18.60	1.85	1.83
2. Mz——R	18.29	3.33	1.87
3. S———R	17.28	2.22	2.71
4. S—Mg—R	20.36	3.70	1.89
5. Mg—R	19.74	2.96	1.43

Remarks: 1) Soil samples were taken from the surface layer of 10 cm depth before rice transplanting, on August 15, 1979.
2) * : Fresh soil samples submerged after dried at room temperature,
**: Fresh soil samples submerged immediately.

Table 5-20. Rice yield with reference to cropping pattern (t/ha)

Cropping pattern	1977	1978	1979	Mean
R	4.96	3.06	4.24	4.09
Mz—R	4.05	3.79	4.44	4.09
S—R	4.19	3.74	5.06	4.33
Mg—R	4.88	4.00	4.36	4.41
Mz—S—R	5.01	4.63	—	—
P—S—R	5.03	4.69	—	—
Mg—S—R	5.17	4.47	4.99	4.88

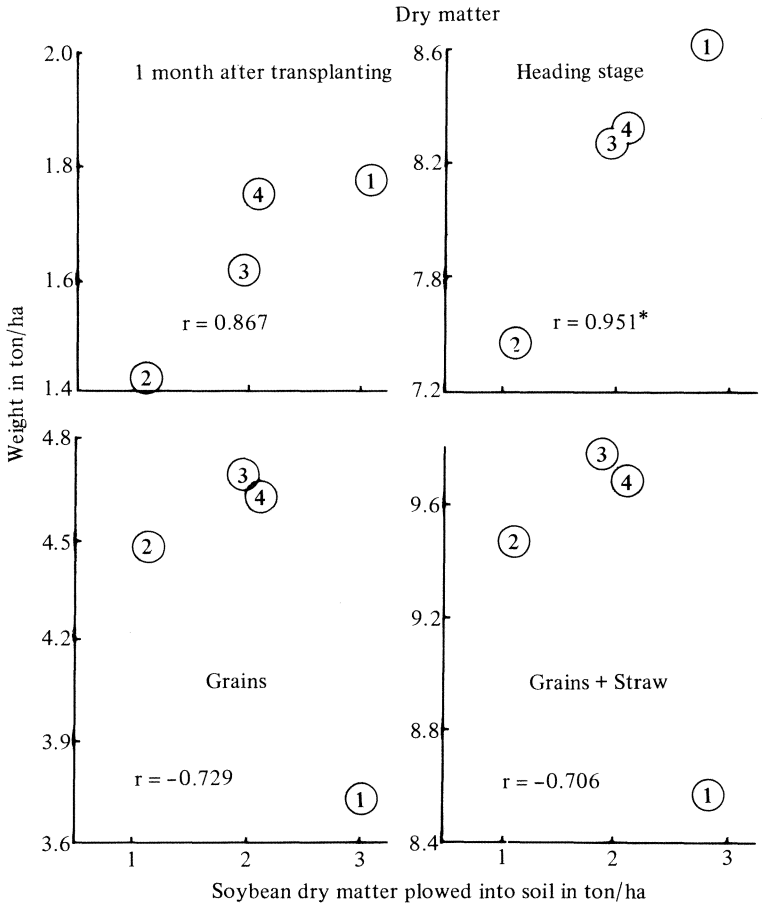
Remarks: Fertilizer application to rice
1977 & 1978: 40—25—0 (N—P—K in kg/ha)
1979: 50—25—0



● Ridge height ○ Soil moisture
** Significant at 1% *** Significant at 0.1% level

Maize in the cropping pattern of Cr-Mz-R was used for measurement.

Fig. 5-1. Relationship between plant height of maize at 28 days after seeding and ridge height or soil moisture (1978)



Remarks : Figures in circles indicate cropping pattern ;
1 : soybean, 2 : mungbean-soybean,
3 : peanut-soybean, 4 : corn-soybean.

Fig. 5-2. Relationship between dry matter production or yield of rice and top weight of soybean plowed into soil before transplanting of rice (1978)